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Assessing the safety features of electronic patient medication record systems used in community pharmacies in England

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WHAT IS ALREADY KNOWN ABOUT THIS SUBJECT

- Electronic patient medication record (ePMR) systems provide alerts about potential drug interactions between previously dispensed and newly prescribed medication.
- It has been suggested that there are problems, such as false alerts and overalerting.

WHAT THIS STUDY ADDS

- This study evaluated the ability of ePMR systems used in community pharmacies in England to alert users about medication-related hazards and errors.
- Alerts are not adequately implemented in most ePMR systems.
- Current systems are unreliable in highlighting clinically significant prescribing hazards other than drug–drug interactions and co-prescriptions.
- Pharmacists should not be over-reliant on ePMR systems in their current state of maturity.

AIMS

To evaluate the ability of electronic patient medication record (ePMR) systems used in community pharmacies in England to detect and alert users about clinical hazards, errors and other safety problems.

METHODS

Between September 2012 and November 2012, direct on-site observational data about the performance of ePMR systems were collected from nine sites. Twenty-eight scenarios were developed by consensus agreement between a general practitioner and two community pharmacists. Each scenario was entered into the ePMR system, and the results obtained from the assessment of six unique systems in nine sites, in terms of the presence or absence of an alert, were recorded onto a prespecified form.

RESULTS

None of the systems produced the correct responses for all of the 28 scenarios tested. Only two systems provided an alert to penicillin sensitivity. No dose or frequency check was observed when processing a prescription for methotrexate. One system did not warn about nonsuitability of aspirin prescribed to a child of 14 years of age. In another system, it was not possible to record a patient's pregnancy status. None of the six systems provided any warning for diclofenac overdose, high initiation dose of morphine sulfate or significant dose increase. Only one of the systems did not produce any spurious alerts.

CONCLUSIONS

The performance of the ePMR systems tested was variable and suboptimal. The findings suggest the need for minimum specifications and standards for ePMR systems to ensure consistency of performance.

Introduction

Pharmacists take numerous steps to ensure the safety of medications and patients in their care. These steps include checking prescriptions and dispensing labels for accuracy, ensuring suitability of medications, doses and directions, and assessing prescriptions for potential problems, such as interactions with other medications and drug allergies. These facilitate reduction in medication errors and dispensing of potentially hazardous drugs and unsafe co-prescriptions [1, 2].

In a recent retrospective case record review study of 1000 adults who died in 2009 in 10 acute hospitals in England, a wide range of problems were identified in patients whose death was judged as preventable. Unacceptable fluid levels and medication problems, such as side-effects, inappropriate use, failure to give prophylactic care and anaphylaxis accounted for 21.1% of the most frequent problems [3]. Wrong dose, frequency, route or quantity, mismatching between patient and medicine, allergy, contraindication and adverse drug reaction have also been identified as errors arising from medication use [4]. Recent work that investigated medication error in general practices in England showed that one in eight patients is subject to a medication error [5]. To achieve improvements in medication and patient safety, the World Health Organization reiterates the requirement for a wide range of actions such as performance improvement, risk management, and provision of a safe healthcare environment, encompassing appropriate use of medicines, equipment safety and safe clinical practice [6].

In the UK, at the time of writing this article, the majority of prescriptions presented to community pharmacies are paper based and these require re-entry of the order into the electronic patient medication record (ePMR) system. A new service, the Electronic Prescription Service (EPS), has been introduced and is being deployed through two key releases. The service allows for electronic transmission of prescriptions from the general practice (GP) surgery to the pharmacy, which means that in those cases, it is possible for the ePMR system to be populated with information automatically from GP systems, but this is still in the roll-out phase and not in widespread use. Pharmacists use their knowledge, with the support of ePMR systems embedded with safety features, to complete their assessment of prescribed medication. Clinical and professional reasons have both been cited as some of the reasons for installing ePMR systems by pharmacy companies [7]. Previous studies have shown ePMR systems to be useful in alerting pharmacists to potential drug interactions between previously dispensed and newly prescribed medication [8].

In many countries around the world, the sensitivity and specificity of safety warnings, the way in which they are presented, what a user gets warned about, and the category and severity level of alerts are some of the areas where variations and problems exist in ePMR systems [9–14]. Other problems include missing alerts, inadequate alert information and false alerts. Overalerting as a result of delays in implementation of prescribing guidance updates, beneficial therapeutic duplication of medications, such as antihypertensives, and use of multiple drug strengths to personalize drug regimens could lead to 'alert fatigue' and automatic behaviour towards alerts without consideration of the implications [9, 12, 15, 16]. Technologies such as ePMR systems have also been known to introduce new errors, such as separation of functions that facilitate double dosing and incompatible orders and fragmented displays that prevent a coherent view of patients' medications [17].

A proactive approach to safety is required in the identification and prevention of potential medication errors and harm to patients [18]. Even though the performance of safety features and alerts in hospital and community pharmacy ePMR systems in some countries is well documented [9, 11–14, 19, 20], such data about community pharmacy ePMR systems in England do not exist. Over one billion prescription items were dispensed in the community in England in 2012 [21]. This number has been steadily increasing over recent years, with greater potential for medication errors as the number of medicines dispensed increases. This increased number of medicines also presents huge opportunities and challenges for pharmacists, to stop errors and harm to patients. In addition, the dispensing stage of the medication use process is usually the last opportunity to stop an error from passing through to the patient in primary care and should remain invulnerable [22].

This study aimed to evaluate the ability of ePMR systems, used in community pharmacies in England, to detect and alert users to a sample of clinically hazardous interactions, errors and problems during pharmacy order entry. Currently, there is no minimum specification for the clinical functionality of ePMR systems used in community pharmacies in England. In this study, we examined systems that have been approved by the National Health Service in England. All these systems have to be capable of using EPS Release 2 (R2) [23].

Methods

This study was part of a larger observational study in eight community pharmacies, exploring the use of ePMR systems and alerts in the practice setting. Firstly, we approached community pharmacies in the Nottinghamshire area, UK. The pharmacies were invited, with permission from their superintendent pharmacists, by post or telephone, to participate in the observational study. The assessment took place in the eight community pharmacies that agreed to participate in the observational study. All but one of the ePMR systems were tested in these community pharmacies. We identified an extra ePMR system, and this system was supplied by the vendor and tested in a demonstration setting. This sample represented all six ePMR systems available in community pharmacies in England in August 2012. Direct, on-site observational data were collected between September 2012 and November 2012. The names of the ePMR systems have been anonymized as S1–S6 to preserve ePMR system and vendor anonymity.

Test scenarios

Prespecified scenarios against which the ePMR systems were to be evaluated were developed to test prompting of clinically important events or the spurious alerting of nonclinically important events. Scenarios were devised by consensus agreement between a general practitioner and two community pharmacists following a review of primary literature; guidance from the British National Formulary 63 [24] and Summary of Product Characteristics. These scenarios included appropriate alerts when contraindicated drugs or hazardous drug–drug combinations were entered into the ePMR systems. The response of the ePMR system was recorded as ‘yes’ where an alert was generated or ‘no’ if the ePMR system did not produce an alert.

Twenty-eight scenarios were used to check for drug–drug interactions, other hazardous situations where evidence exists that an ePMR system should alert the user about potential errors and harm during order entry, and spurious alerts. These scenarios included various patient demographics and conditions such as hypertension, asthma and rheumatoid arthritis. Some of the scenarios were adapted from previous studies described elsewhere [12, 25]. Tables 1–3 show the clinical rationale for each of the scenarios tested. The scenarios in Tables 1 and 2 are potentially hazardous based on the clinical rationale outlined above and should trigger an alert in the ePMR system. The scenarios in Table 3 should not trigger an alert. These include scenarios where other drugs in the class have clinically significant interactions but the test drug does not, or as a result of concomitant use being downgraded due to new evidence.

Rationale for the test scenarios

The rationale for the tests is described in Tables 1–3. The first set of tests, described in Table 1, was designed to test the performance of ePMR systems with respect to checking drug–drug interactions and hazardous co-prescriptions. The second set, described in Table 2, was designed to test information that could have been provided either from the prescription or from the patient medication record without recourse directly to the general practitioner. The third set, described in Table 3, looked at the potential for overalerting. Allergies and pregnancy data are not routinely communicated directly on prescriptions. Nevertheless, pharmacists may be aware of this information directly from the patient and would expect to receive appropriate alerts if the information was recorded in the ePMR system.

Test process

One researcher (OO) visited each participating pharmacy at a mutually convenient time to collect relevant data about the performance of their pharmacy’s ePMR system. Dummy patient data and the scenarios were entered into the ePMR system. All scenarios were tested on each of the

Table 1

Clinical scenarios involving hazardous co-prescriptions and interactions

Test	Dispensing scenario (alert expected = Yes)	Rationale
A1	Sildenafil prescribed to a patient who is also receiving a nitrate	Sildenafil significantly enhances hypotensive effect of nitrates; avoid concomitant use
A2	Ciprofloxacin prescribed to a patient who is taking ciclosporin	Increased risk of nephrotoxicity when quinolones are given with ciclosporin
A3	Clarithromycin prescribed to a patient who is taking digoxin	Macrolides increase plasma concentration of digoxin; increased risk of toxicity
A4	Erythromycin prescribed to a patient who is taking simvastatin, with no evidence that the patient has been advised to stop the simvastatin whilst taking the antibiotic	Increased risk of myopathy when simvastatin is given with erythromycin
A5	Ibuprofen prescribed to a patient who is taking lithium carbonate	Excretion of lithium is reduced by nonsteroidal anti-inflammatory drugs; increased risk of toxicity
A6	Verapamil prescribed to a patient who is taking atenolol	Taking verapamil with β-blocker may lead to severe hypotension and heart failure
A7	Naproxen prescribed to a patient who is taking warfarin	Anticoagulant effect of coumarins is possibly enhanced by nonsteroidal anti-inflammatory drugs
A8	Tagamet prescribed to a patient who is taking warfarin	Metabolism of coumarins is inhibited by cimetidine, the active ingredient in Tagamet, leading to enhanced anticoagulant effect
A9	Fluvastatin prescribed to a patient who is taking warfarin	Fluvastatin enhances the anticoagulant effect of coumarins
A10	Microgynon prescribed to a patient who is on carbamazepine	Carbamazepine accelerates the metabolism of estrogens; reduced contraceptive effect
A11	St John’s Wort prescribed to a patient who is taking fluoxetine	Increased serotonergic effects when fluoxetine is given with St John’s Wort; avoid concomitant use
A12	Tramacet prescribed to a patient who is taking paracetamol	Tramacet contains tramadol and paracetamol. Duplication of paracetamol and increased risk of paracetamol toxicity

Table 2

Clinical scenarios in relation to drug-allergies, contraindications, inappropriate doses, drug-route suitability, high-dose initiation of medicines and significant dose increase

Test	Dispensing scenario tested (alert expected = Yes)	Rationale
B. Drug allergy		
B1	Fluarix vaccine prescribed to a patient with egg allergy	Summary of Product Characteristics: contraindicated. British National Formulary: individuals with a history of egg allergy can be immunized with either an egg-free influenza vaccine, if available, or an influenza vaccine with an ovalbumin content <120 ng ml^{-1} (facilities should be available to treat anaphylaxis). The ovalbumin content of Fluarix is <100 ng ml^{-1}
B2	Phenoxymethylpenicillin prescribed to a patient with penicillin allergy	Contraindicated
C. Contraindications (including age, gender and condition)		
C1	Aspirin 300 mg tablet to be taken every 6 h when required (112 tablets), prescribed to a child of 14 years	Contraindicated in children <16 years; Reye's syndrome
C2	Acrivastine 8 mg capsule to be taken three times daily (84 capsules) prescribed to an elderly patient of 70 years	Contraindicated; may be more sensitive to side-effects, especially drowsiness
C3	Finasteride prescribed to a female patient	Finasteride is not indicated for use in women or children
C4	Methotrexate prescribed in pregnancy	Contraindicated
C5	Propranolol 10 mg tablet to be taken four times daily (112 tablets) prescribed to a patient with asthma who is on salbutamol	β-Blockers, including those considered to be cardioselective (e.g. propranolol), should usually be avoided in patients with a history of asthma or bronchospasm
D. Dose check		
D1	Diclofenac sodium 50 mg tablet to be taken four times daily (112 tablets)	The daily dose of 200 mg is more than the maximum daily dose of 75–150 mg in two to three divided doses recommended by the British National Formulary for oral intake
D2	Methotrexate 2.5 mg tablets, 15 mg to be taken daily (42 tablets)	Methotrexate dose is once weekly
E. Drug-route check		
E1	Timolol eye drops prescribed to a patient with asthma who is on salbutamol	British National Formulary states that β-blockers, even those with apparent cardioselectivity, should not be used in patients with asthma or a history of obstructive airways disease, unless no alternative treatment is available. In such cases, the risk of inducing bronchospasm should be appreciated and appropriate precautions taken
F. High-dose initiation of medicines and significant dose increase		
F1	MST Continus 100 mg tablets prescribed to a patient who had 10 mg recorded in the electronic patient medication record system	Significant dose increase
F2	Morphine sulfate solution 20 mg ml^{-1}, 5 ml to be taken every 4–6 h when required	High-dose initiation

Table 3

Clinical scenarios where an alert would not be expected

Test	Dispensing scenario (alert expected = NO)	Rationale
G1	Pravastatin prescribed to a patient who is already taking warfarin	Unlike some statins, pravastatin is not known to affect the effect of anticoagulants. This scenario checks whether interactions are picked up at drug class, product level or both
G2	Amoxicillin prescribed to a patient who is on Microgynon	Current recommendations issued by the Faculty of Sexual and Reproductive Health Care Clinical Effectiveness Unit in January 2011 are that no additional contraceptive precautions are required when combined oral contraceptives are used with non-enzyme-inducing antibiotics, unless diarrhoea or vomiting occurs [26]
G3	Atenolol prescribed to a patient who is already taking amlodipine	Calcium-channel blocker and β-blocker combination may be used to treat high blood pressure or to relieve angina pain when either drug alone proves inadequate
G4*	Atenolol 75 mg, once daily (28 day treatment)	Requires dispensing of 25 mg and 50 mg tablets because the 75 mg product is not commercially available. Maximum daily dose can be up to 200 mg depending on the condition being treated

*Drug-doubling.

systems once. In the scenarios we used, the dosage instructions were created using the ePMR system's dose codes and so we would expect the ePMR system to be capable of recognizing an error. Data were recorded on predesigned data-extraction sheets. Where a scenario required a historical medication record for an assessment, entry of any 'newly prescribed' medication was done at least 1 day after the initial entry of the 'historical' medication. Correct response was recorded if an alert was presented on screen when an alert was expected, or an alert was not displayed on screen when it was not expected. The study was reviewed by the University of Nottingham, Medical School Research Ethics Committee and was given a favourable opinion. National Health Service research and development permission was obtained from Nottinghamshire Healthcare NHS Trust.

Results

Five unique ePMR systems licenced for EPS R2 in England were tested in the eight participating pharmacies, with a sixth ePMR system assessed in a demonstration setting. All the six ePMR systems assessed had safety features in them, alerting users about potential hazardous situations. Four of the eight participating pharmacies were using the same ePMR system (System S2) at the time of the assessment; the system responses observed in all four sites were the same. No system produced the anticipated responses for all of the 28 scenarios tested. Alerts were displayed in a pop-up window (two systems), in a fixed area for messages (one system), on a separate screen (one system) or as a dual warning in both a pop-up window and in a fixed message area (two systems).

The systems correctly identified the majority of hazardous co-prescriptions and drug–drug interactions (Table 4). Two of the ePMR systems identified all the 12 interactions that were assessed in this category. Systems S1 and S2 failed to highlight the potential for digoxin toxicity when co-prescribed with clarithromycin. Systems S2 and S3 failed to notify the user about potential hazards from coincident prescribing of paracetamol, when generic paracetamol and Tramacet (a product containing tramadol and paracetamol) were prescribed for the same patient on subsequent days. System S6 did not highlight the clinically significant interaction between fluoxetine and St John's Wort. Further investigation of the settings for S6 highlighted that St John's Wort drug name was not mapped to a physical product.

Table 5 shows the ability of the ePMR systems to highlight drug-allergy issues, contraindications, inappropriate doses, drug-route suitability, issues with high-dose initiation of medicines and significant dose increase assessment.

None of the systems produced an alert for all the scenarios. System S4 produced the most alerts (for four of the 12 scenarios), with system S1 providing an alert in only one of the scenarios. None of the systems identified the potential allergy to Fluarix, and only S2 and S6 provided an alert to the penicillin sensitivity. Further investigation of the systems showed that in S4 and S5, drug allergy must be recorded per product for allergy checking to take place. With respect to checking for contraindications as a result of age, gender or co-morbidity, a wide range of system responses were observed. System S4 successfully alerted for all of the scenarios presented, S1 did not alert for any of the scenarios and the other systems alerted in less than half of the scenarios. Systems S1, S2 and S5 informed about nonsuitability of aspirin use (C1) in a child of 14 years of age by recording the information on the prescription label or in the message area irrespective of the age of the patient. System S3 did both. It was not possible to record in S6 that a patient was pregnant (C4).

None of the systems identified the overdose of diclofenac in D1. Five of the six systems provided a warning about the use of methotrexate (D2); however, the alert was provided irrespective of the frequency regimen of methotrexate (weekly or daily). None of the ePMR systems appeared to check the dosing frequency entered. The alerts displayed in four of the ePMR systems were based on the National Patient Safety Agency directive regarding weekly dosing of oral methotrexate [26]. In S4,

Table 4

Hazardous co-prescriptions and interactions alert responses by electronic patient medication record systems (alert generated = Yes; no alert generated = NO)

Test	Dispensing scenario tested	Electronic patient medication record system S1	S2	S3	S4	S5	S6
A1	Sildenafil prescribed to a patient who is also receiving a nitrate	Yes	Yes	Yes	Yes	Yes	Yes
A2	Ciprofloxacin prescribed to a patient who is taking ciclosporin	Yes	Yes	Yes	Yes	Yes	Yes
A3	Clarithromycin prescribed to a patient who is taking digoxin	NO	NO	Yes	Yes	Yes	Yes
A4	Erythromycin prescribed to a patient who is taking simvastatin, with no evidence that the patient has been advised to stop the simvastatin whilst taking the antibiotic	Yes	Yes	Yes	Yes	Yes	Yes
A5	Ibuprofen prescribed to a patient who is taking lithium carbonate	Yes	Yes	Yes	Yes	Yes	Yes
A6	Verapamil prescribed to a patient who is taking atenolol	Yes	Yes	Yes	Yes	Yes	Yes
A7	Naproxen prescribed to a patient who is taking warfarin	Yes	Yes	Yes	Yes	Yes	Yes
A8	Tagamet prescribed to a patient who is taking warfarin	Yes	Yes	Yes	Yes	Yes	Yes
A9	Fluvastatin prescribed to a patient who is taking warfarin	Yes	Yes	Yes	Yes	Yes	Yes
A10	Microgynon prescribed to a patient who is on carbamazepine	Yes	Yes	Yes	Yes	Yes	Yes
A11	St John's Wort prescribed to a patient who is taking fluoxetine	Yes	Yes	Yes	Yes	Yes	NO
A12	Tramacet prescribed to a patient who is already taking paracetamol	Yes	NO	NO	Yes	Yes	Yes

Table 5

Responses by electronic patient medication record systems in relation to drug allergies, contraindications, inappropriate doses, drug-route suitability, high-dose initiation of medicines and significant dose increase (alert generated = Yes; no alert generated = NO)

Test	Dispensing scenario tested	Electronic patient medication record system S1	S2	S3	S4	S5	S6
B. Drug allergy							
B1	Fluarix vaccine prescribed to a patient with egg allergy	NO	NO	NO	NO	NO	NO
B2	Phenoxymethylpenicillin prescribed to a patient with penicillin allergy	NO	Yes	NO	NO	NO	Yes
C. Contraindications (including age, gender and condition)							
C1	Aspirin prescribed to a child of 14 years	NO	NO	Yes	Yes	NO	NO
C2	Acrivastine prescribed to an elderly patient of 70 years	NO	NO	NO	Yes	NO	NO
C3	Finasteride prescribed to a female patient	NO	NO	NO	Yes	NO	NO
C4	Methotrexate prescribed in pregnancy	NO	NO	NO	Yes	Yes	NO
C5	Propranolol prescribed to a patient with asthma who is on salbutamol	NO	Yes	Yes	Yes	Yes	Yes
D. Dose check							
D1	Diclofenac tablets prescribed above the maximum daily dose recommended by the British National Formulary	NO	NO	NO	NO	NO	NO
D2	Methotrexate prescribed on a daily basis	Yes	Yes	NO	Yes	Yes	Yes
E. Drug-route check							
E1	Timolol eye drops prescribed to a patient with salbutamol already in the patient medical record	NO	NO	Yes	NO	Yes	NO
F. High-dose initiation of medicines and significant dose increase							
F1	MST Continus 100 mg tablets prescribed to a patient who had 10 mg tablets recorded in the electronic patient medication record system	NO	NO	NO	NO	NO	NO
F2	Morphine sulfate concentrated oral solution prescribed to an opiate-naïve patient	NO	NO	NO	NO	NO	NO

Table 6

Responses by electronic patient medication record systems in clinical scenarios where an alert would not be expected (alert generated = Yes; no alert generated = NO)

Test	Dispensing scenario tested	Electronic patient medication record system S1	S2	S3	S4	S5	S6
G1	Pravastatin prescribed to a patient who is already taking warfarin to investigate whether electronic patient medication record alerts are attached to individual drugs or whether they are applied at the class level	NO	NO	Yes	NO	Yes	NO
G2	Amoxicillin prescribed to a patient who is on Microgynon to see whether systems were being updated in line with more recently updated guidance	Yes	NO	Yes	NO	NO	Yes
G3	Atenolol prescribed to a patient who is already taking amlodipine	NO	NO	Yes	NO	Yes	Yes
G4*	Atenolol 75 mg (25 mg + 50 mg), once daily (28 day treatment)	NO	NO	NO	Yes	NO	NO

*Drug-doubling.

the weekly regimen was advised in the counselling section of the ePMR software; however, this was contrary to the specific alert layout recommendations of the National Patient Safety Agency. No alert was provided by S3.

Scenario E1 was similar to C5; β-adrenoceptor blocking drugs (in this case, timolol eye drops) should not be used in asthmatic patients (even when administered as eye drops). Unlike C5, where five of the systems correctly alerted the user, for E1 four of the systems failed to warn the dispenser about the potential for harm. Scenarios F1 and F2 were concerned with instances where patients should either be started on a low dose of the medication or should have doses changed gradually. None of the six systems tested provided any warning when presented with these scenarios.

Table 6 shows the results when systems were tested to assess whether unnecessary alerts were provided. Many statins interact with warfarin; however, pravastatin has been shown not to interact. In G1, four of the systems correctly showed no alert, but systems S3 and S5 incorrectly produced alerts. The scenario G2, involving the combined oral contraceptive Microgynon and the antibiotic amoxicillin, was included to assess whether new guidance had been implemented to no longer warn against concomitant non-enzyme-inducing antibiotic use with combined oral contraceptives [27]. Three ePMR systems presented an alert contrary to the revised guidance. Scenario G3 looked at the co-prescribing of two antihypertensive drugs, a very common, and usually appropriate, practice in patients with high blood pressure. Three of the systems produced alerts about the use of two similar medicines, whereas three did not. The prescribing of two strengths of the same medicine to achieve a dose not available as a single tablet was tested in G4. Five of the systems appropriately produced no alert.

Discussion

The results suggest that current ePMR systems have some deficiencies with respect to highlighting clinical hazards such as drug–drug interactions, co-prescriptions, allergies, contraindications and inappropriate dosing. Although some progress has been made in the development of ePMR systems over the years, there is still a long way to go in bringing the systems up to the level of performance that is now required in clinical practice.

The tests described in Table 1 assessed the performance of ePMR systems with respect to checking drug–drug interactions and hazardous co-prescriptions. All of the medicines a patient receives from a pharmacy are recorded in the ePMR system, so the information is generally readily available to perform these safety checks. However, this is only the case when patients use the same pharmacy. Nevertheless, there would appear to be some cases where known drug–drug interactions are not warned against. If pharmacists rely on the ePMR system to identify these hazardous events, then this is a concern for patient safety. This study was not designed to identify the reasoning behind these events being missed, and further work would be needed to understand why this was the case.

Pharmacists are considered to be experts in medicines and, as well as being aware of specific drug interactions, they are also required to ensure that medicines are used safely based on other key parameters, such as allergies, co-morbidities and issues associated with the age and gender of the patient. The ePMR systems had highly variable performance when checking for issues other than drug–drug interactions. In many cases, few or none of the systems identified the potentially hazardous prescribing. Often, the pharmacist has available only the information presented on the prescription and in the ePMR system along with the information provided by the patient.

In the tests relating to information that could have been provided either from the prescription or from the patient medication record, some of the systems tested were unable to record the required information, such as allergy status, thus preventing appropriate checks being made by the ePMR system. In one instance, allergies could be recorded but these are required to be identified against each medicine; for example, a patient with a penicillin allergy would require an allergy marker being placed against each type of penicillin-based medicine (of which at least six are routinely used in community practice in England). Where allergies could be recorded, none of the systems identified the potential issues with the Fluarix vaccine.

The responses to items prescribed inappropriately to patients based on their age were commonly absent, with only one system correctly identifying both hazardous events. All computer-generated prescriptions now include both the age and date of birth, which can also be verified easily by the patient at the point of dispensing. With this availability, it is surprising that the facility for the ePMR system to verify appropriateness based on age is not generally present.

Our tests showed that the alert for oral methotrexate appeared irrespective of the frequency entered on the label, potentially allowing hazardous daily dosing to be overlooked because this warning appears whether the frequency is correct or not. There was no alert in S3, perhaps due to oversight, lack of awareness of the existence of the National Patient Safety Agency recommendation, or other reasons best known to the pharmacy software vendor company.

In relation to prescribing of morphine, none of the systems alerted to the hazardous practice of initial prescribing of a high dose of medicines to patients or making sudden increases in dose. Given the potential for opioids, such as morphine sulfate, to cause harm to patients [4], high initiation dose and sudden dose increase should alert the user of the system to enable appropriate collaborative management of this potential clinical hazard to take place between the pharmacist and the prescriber and, where relevant, in conjunction with the patient.

It has been reported that alert fatigue can occur when excessive alerts are presented, potentially resulting in important alerts being ignored by the end user [28, 29]. In the tests to check the potential for overalerting, two of the six systems in test G1 triggered unnecessary alerts, suggesting that some systems generate alerts at the drug class level rather than the individual drug level, which may lead to an overpresentation of warnings. Three of the six systems in test G2 provided unnecessary warnings about the use of Microgynon with amoxicillin. This suggests that some systems are not updated in a timely fashion when new guidance becomes available.

Implications for policy and practice

Policy The results of this study have shown that all of the ePMR systems have inadequacies and do not always produce the same alerts. Given that the ePMR system is intended to be a core element of the service provision in pharmacy, it would seem appropriate for the information to be consistent across systems. At present there is no core specification for the types and content of safety features in ePMR systems in the UK, and there is an urgent need to produce one.

Practice With no core specification and standard system response, it falls to the clinical knowledge of the pharmacist to ensure that all of the items they dispense are clinically appropriate and safe. Many pharmacists work in one pharmacy, but there are some who work in different pharmacies providing cover for days off and holidays. As these systems provide different responses to clinical situations, the pharmacist needs to be fully aware of how the ePMR system they are using will respond, if at all, in a given situation. This work highlights the need for pharmacists not to be over-reliant on ePMR systems.

Strengths and limitations

Strengths One of the strengths of this study is that we tested six of the seven EPS R2 approved ePMR systems available in practice in August 2012, representing almost complete coverage of systems used in community pharmacies in England. This study provides a picture of the ability of ePMR systems and their safety features, in their current state of maturity, to pick up potential clinical hazards and medication errors during pharmacy order entry. It is the first assessment of its type to look at the safety aspects of ePMR systems approved for EPS R2, in the community pharmacy setting in England.

Limitations This study was an assessment of the ability of the systems to inform users about potentially hazardous situations during order entry. It provides information about the current state of maturity of the systems. The assessment was not conducted as a specific test of the sensitivity or specificity of the systems, because the underlying algorithms were not reviewed. It also did not look at how pharmacy professionals react to safety alerts or how they perceive them in practice. Further research would be needed to address these issues.

It is noteworthy that some of the scenarios used in the assessment may, on occasion, be violated for a specific patient; for example, when treatment is started by a specialist consultant in secondary care for continuation in primary care. It was not the intention of this study to allow for these situations, thereby focusing on more routine prescribing in general practice.

Conclusions

The performance of the ePMR systems tested was variable and suboptimal. The findings suggest the need for minimum specifications and standards for ePMR systems to ensure consistency of performance.

Competing Interests

All authors have completed the Unified Competing Interest form at http://www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.

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